AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

NEW YORK, September 20th, 1893.

The seventy-ninth meeting of the INSTITUTE was called to order by President Houston at 8 o'clock, P. M.

THE PRESIDENT :—It has been suggested, that, since the paper announced for the evening, by Mr. D. McFarlan Moore, from its interest may call forth prolonged discussion, that the President's inaugural address be postponed until after its reading. I will therefore call on Mr. Moore to read that paper as soon as the Secretary has made some announcements.

THE SECRETARY :—At the Council meeting this afternoon the following associate members were elected :

Name.	Address.	Endorsers.
ALBANESE, G. SACCO	Inspector on Electrical Construction, Electrical Engineering Department, World's Fair, Chicago, Ill.	R. H. Pierce. L. Stieringer. F. W. Tischendoerfer.
ALMON, G. H.	Supt. Construction, General Electric Co., 620 Atlantic Ave., Boston, Mass.	C. W. Pike. H. A. Foster. R. W. Pope.
ANDERSON, W. E.	Professor of Physics and Electrical Engineering, Virginia A and M College, Blacksburg, Va.	H. A. Foster. W. J. Hammer. R. W. Pope.
AUERBACHER, LOUIS J.	Electrician and Head Salesman, The E. S. Greeley & Co., 5 and 7 Dey St., New York City.	R. W. Pope. W. J. Hammer. C. W. Pike.
BARNES, EDWARD A.	Electrical Expert, Fort Wayne Elec- tric Co., Electricity Bldg. World's Fair, Ill.	H. A. Foster. F. S. Hunting. L. Stieringer.
BLAKE, THEODORE W.	Electrician, National India Rubber Co., Bristol, R. I.	Hammond V. Hayes. John C. Lee. F. A. Pickernell.
BOARDMAN, HARRY B.	Wisconsin Telephone Co., 1530 Grand Avenue, Milwaukee, Wis.	D. C. Jackson. N. S. Keith. R. W. Pope.
BOGGS, LEMUEL STEARNS,	Electrical Engineering Department, World's Fair, Chicago, Ill.	R. H. Pierce. Geo. M. Mayer. R. W. Pope.

BRAGG, CHARLES A.	Manager Phila. Agency, Westinghouse Electric & Mfg. Co., Girard Bldg., Philadelphia, Pa.	R. W. Pope. Cecil P. Poole. A. L. Johnston.
BRENNER, WILLIAM H.	Electrical Engineer, Montreal Street Railway Co., Montreal, P. Q.	J. H. Vail. Wm. J. Jenks. A. E. Winchester.
BRIXEY, W. R.	Proprietor and Manufacturer, Day's Kerite Wire and Cables, 203 Broadway, New York City	R. W. Pope. T. C. Martin. Geo. M. Phelps.
BURTON, WILLIAM C.	Edison Illuminating Co., 238 27th St., Milwaukee, Wis.	R. W. Pope. D. C. Jackson. H. A. Foster.
CETTA, WILLIAM J.	Electrician, General Electric Co., 398 Broad Street, Newark, N. J.	Wm. J. Hammer. H. A. Foster. R. W. Pope.
CREAGHEAD, THOMAS J.	President and General Manager, Creaghead Engineering Co., 296 Plum St., Cincinnati, O.	Chas. F. Scott. L. B. Stillwell. Albert Schmid.
DECKER, DELBERT H.	Solicitor of Patents, with H. C. Townsend, 5 Beekman St., New York City.	H. C. Townsend. C. O. Mailloux. Ed. L. Nichols.
DODGE, OMENZO G.	Professor of Math. U. S. Navy, Chief Inspector, Electrical Engineering Dept., World's Fair, Chicago, Ill.	R. H. Pierce. Geo. M. Mayer. H. A. Foster.
DOW, ALEXANDER	Engineer, Chicago District, Brush Electric Co., Box 433, Wheaton, Ill.	Geo. Cutter. Charles Wirt. R. W. Pope.
EICKEMEYER, RUDOLF	Pres't, Eickemeyer & Osterheld Mfg. Co., Yonkers, N. Y.	C. P. Steinmetz. R. W. Pope. H. A. Foster.
FITZMAURICE, JAMES S.	Chief Engineer, The Electric Light Branch, 300 Kent Street, Sydney, N. S. W.	Gustave Fischer. W. J. Spruson. R. W. Pope.
FLEGEL, GEO. C.	Electrical Editor, The Railroad Telegrapher, Argos, Ind.	R. W. Pope. H. A. Foster. M. O'Dea.
FRENCH, THOMAS, JR.	Professor of Physics, University of Cincinnati, Avondale, Cincinnati, O.	W. J. Hammer. H. A. Foster. R. W. Pope.
GREENE, S. DANA,	Assistant General Manager, General Electric Co., 44 Broad St., New York City.	W. J. Hammer. F. J. Sprague. T. C. Martin.
HAMMATT, CLARENCE S.	Supt., Jacksonville Electric Light Co., Jacksonville, Fla.	N. S. Keith, A. F. McKissick. R. W. Pope.
HASKINS, CLARK CARYL	Electric Light Inspector of Chicago, 582 West Congress St., Chicago, Ill.	R. W. Pope. G. A. Hamilton. T. C. Martin.
IRVING, FRANK K.	Consulting Electrician, Franklin Electric Co., 67 McDougal St., Brooklyn, N. Y.	E. T. Birdsall. T. Wolcott. L. Wm. Serrell.
IWADARE, KUNIHIKO	Electrician, Osaka Electric Light Co., Osaka, Japan.	A. E. Wiener. James Burke. Harry N. Marvin.

JOHNSON, J. N.	Electrician in Cable Dept., Western Union Tel. Co., 16 Broad Street, New York City.	John L. Hall. R. W. Pope. L. A. McCarthy.
KELLER, E. E.	Manager and General Supt. of Exposition Work, Westinghouse Electric and Mfg. Co., 5506 Monroe Ave., Chicago.	R. W. Pope. R. H. Pierce. R. N. Bayles.
KIRKEGAARD, J. GEORG	General Incandescent Arc Light Co., 172 President Street, Brooklyn, N. Y.	W. J. Johnston. W. D. Weaver. W. A. Rosenbaum.
MERRILL, E. A.	Electrical Engineer, Pierce & Miller Engineering Co., 42 Cortlandt St., New York City.	H. L. Lufkin. A. C. Crehore. Cary T. Hutchinson.
MOTT, S. D.	Electrical Engineer, Passaic, N. J.	Wm. J. Hammer. W. C. Lawton. W. T. M. Mottram.
NUTTING, SAMUEL E.	Electrician and Supt., Nutting Electric Mfg. Co., 241 So. Scoville Ave., Oak Park, Ill.	Wm. D. Ray. L. L. Summers. Carl K. MacFadden.
PAUL, J. S.	Post-Graduate Student in Civil and Electrical Engineering, Princeton College, Princeton, N. J.	W. J. Hammer. H. A. Foster. R. W. Pope.
PEDERSEN, FREDERICK MALLING	Assistant Electrical Engineer, Crocker-Wheeler Electric Co., 327 W. 34th St., New York City,	M. I. Pupin. F. B. Crocker. Gano S. Dunn.
REBER, SAMUEL	Lieut. U. S. Army, Johns Hopkins University, Baltimore, Md.	D. C. Jackson. Harris J. Ryan. Louis Duncan.
ROSS, NORMAN N.	Electrical Engineer, Canadian General Electric Co., 350 Main St., Winnipeg, Manitoba.	W. M. Rutherford. John Langton. R. W. Pope.
SCHOEN, ALLEN MCGEE	Electrician, South Eastern Tariff Association, Atlanta, Ga.	A. F. McKissick. R. W. Pope. Thos. D. Lockwood.
SHRADER, WILLIAM	Professor of Electrical Engineering, University of Missouri, Columbia, Mo.	R. W. Pope. Harris J. Ryan. Brown Ayres.
SEITZINGER, HARRY M.	Consulting and Constructing Engineer, Wilkesbarre, Pa.	F. N. Sanborn. R. W. Pope. G. A. Hamilton.
STEVENSON, EDWARD W.	Electrician, Brush Electric Illuminating Co., 210 Elizabeth St., New York City.	T. C. Martin. Geo. M. Phelps. A. E. Kennelly.
STRATTON, MILTON G.	Assistant Electrician, Lawrence Gas Co., 256 Essex Street, Lawrence Mass.	Walter C. Fish. F. Sheble. C. J. R. Humphreys.
SVENTORZETZKY, CAPT. LOUDOMER	Military Engineering Academy, St. Petersburg, Russia.	R. W. Pope. N. S. Keith. H. Cushman.
WAIT, HENRY H.	Assistant Electrical Engineer, Western Electric Co., 4919 Madison Ave., Chicago, Ill.	E. M. Barton. C. R. Cross. Thos. D. Lockwood.
WARNER, ERNEST P.	Electrical Engineer, Western Electric Co., 227 So. Clinton St., Chicago, Ill.	Thos. D. Lockwood. R. W. Pope. H. A. Foster.

WEST, JULIUS HENRIK	Electrical Engineer, 3743 Locust St., Philadelphia, Pa.	R. W. Pope. H. A. Foster. N. S. Keith.
WHITTEMORE, CHARLES F.	Secretary and General Supt. Davis Electrical Works, Chicopee Falls, Mass.	Ed. L. Nichols, H. J. Ryan. J. W. Hyde.
WORSWICK, A. E.	Electrical Engineer, Mutual Light and Power Co., Montgomery, Ala.	A. F. McKissick. R. W. Pope. N. S. Keith.
WRAY, J. GLEN	Cable Tester, Chicago Telephone Co., 104 Linn St., Janesville, Wis.	A. V. Abbott. D. C. Jackson. John E. Davies.

THE PRESIDENT:—I take great pleasure in introducing to you Mr. D. McFarlan Moore, who will read a paper entitled "A New Method for the Control of Electric Energy."

A NEW METHOD FOR THE CONTROL OF ELECTRIC ENERGY.

BY D. Mc FARLAN MOORE.

The rapid growth of electrical science, and the almost daily unprecedented addition to it of new inventions, have caused those well versed in the present state of the art to greet new theories with a certain amount of doubt, owing to the large number of false alarms that have been sounded to tell the world that all present theories and methods will, in the future, be history; and that a new and revolutionizing principle has been discovered.

Be that as it may, there is reason to believe that this paper treats largely of an heretofore uninvestigated branch of electrical science and phenomena which may be of great value to the commercial world, and of even greater interest to the scientific world.

The key to this branch of science may be expressed in a few words, viz:—A varying-in-pressure contact in a vacuum, produced by a variable magnetic field.

The present means for the control of electric currents—ohmic resistance—is crude at its best, as in any form it is an uneconomical device. All existing forms of rheostats, regulators, resistance boxes, controllers, etc., are bulky, clumsy means for accomplishing a desired object. This is conspicuously illustrated in the case of stage regulators, which often occupy valuable floor space and consist of a tremendous weight and length of wire. That the design of apparatus for controlling current is a matter of great importance and is essential to all electrical installations, is exhibited in the fact that over half of the

catalogues issued by electric manufacturing companies are given up to this class of electrical goods. Many problems in electrical engineering are considered impracticable, simply because of the weight and space required for resistance to enable the control of the current as desired.

When one takes into consideration the multitude of switches of every conceivable shape, construction and design, but all having one aim in view—which none perfectly accomplish—viz:—to break a current without deleterious sparking, it seems that, as all are designed on the same principle, a new principle should be employed which would perfectly accomplish the object desired, that is; break the current with practically no sparking. It would also be a very convenient feature if each switch would control the brilliancy of all lights on the circuit which it controls.

The regulation of intensity of the incandescence of an electric filament has been a problem, the solution of which has been sought after by electricians in general the world over, and partial success has been attained by the use of the only known means, “dead resistance;” but this method can never be commercially successful, on account of very objectionable bulk, weight and heating of the resistance.

The public in general demands the control of electric lamps and the great convenience gained thereby.

The massive regulators of dynamos, and starting boxes of motors should be supplanted by devices occupying but a few cubic inches of space. This is especially the case where the motor is not stationary, as in electric railway work.

There is room for a cheap ampere meter, and still more room for a cheap mechanism to be used as an electric gauge; that is, an instrument which can be adjusted or set so that a current that has passed through it will have any desired quantity or quality. This device could be substituted in place of fusible cutouts and the multitude of appliances of a similar nature. It would be of great value in telegraphy. The application of electricity in medicine should also be improved. Lastly, the reducing of phosphorescent lighting to a commercial basis is desirable.

It is hoped a solution of these and many other problems lies in the principle stated at the beginning of this paper, *i.e.*, a varying-in-pressure contact in a vacuum produced by a variable magnetic field, and it is doubly valuable in that it can be applied

both to the alternating and the direct current. One of the simplest forms of apparatus designed for meeting these conditions is shown in Fig. 1. The varying-in-pressure contact is shown at *A*, caused by the variable magnetic field due to the movement of the magnet *B* by thumb screw *C*. The evacuated bulb *F* contains the armature *D*, supported by spring *E*, permitting it to vibrate rapidly, producing pulsations or interruptions of the current. The rate or degree of these interruptions depends on the strength of the magnetic field surrounding the armature (in this case acting through the glass), which in turn depends on the distance of the magnet from it, varying inversely as the square of the distance. Varying the magnetic field, and therefore the pressure on the contacts, changes the amperes and volts of the current passing through the device. With properly de-

FIG. 1.

signed apparatus the movement of the armature is so slight that to all appearances one would think it at rest. In the discussion of this method of current control, let us select that form of translating device known as the incandescent electric lamp. Fig. 2 is a diagram showing the action of a vibrator in series with a lamp, without the contacts in a vacuum.

Its action is as follows:—Contact made at *A*; current flows through magnet and armature is attracted, breaking the circuit; magnet loses its power and spring *s* again closes the circuit.

Fig. 3 shows the device as applied to each individual lamp, and it will be noted that in this case the vacuum of the lamp is utilized for the vacuum of the contacts as well. The size of the armature is made as light and small as possible not only on account of the general law of all mechanical construction, viz:

make moving parts as light as is compatible with strength so that the position of the lamp will have no effect on the incandescence of the filament, but to minimize the amount of residual gas in the metal composing the armature, as any foreign gas will be detrimental to the filament.

In Fig. 4 a socket of ordinary dimensions is shown constructed on the same principle. A socket of this kind can be adjusted to regulate a lamp of almost any c. p. within limits.

In both of these instances the movement of the magnet pro-

FIG. 2.

duces the regulation, but it is evident the result would be the same by either the movement of the vacuum or the core of the magnet, as shown at A, or by throwing in and out coils of the magnet. The filament emits continuous light with an illuminating power corresponding to the rate of vibration of the armature. When the armature is not within the inductive distance of the magnet, it is at rest and the filament being in circuit, the light is at its maximum. An attachment to the means for adjusting the magnet is used to break the circuit when it is desired to

extinguish the light. Tests show that the volts and amperes vary directly with the light. This is apparent from the following table, a 16 c. p. lamp being used :

Amperes.	Voltmeter No. 2 (see Fig. 2).	Voltmeter No. 1.
.42 full c. p.	115	0
.30	84	31
.17	52	63
.11	35	80
.07	20	95
.04	15	100
.03	10	105
.02 just visible	5	110

Still lower readings were taken, but below .02 ampere the heating of the filament was not discernible by the eye.

As shown by the readings of voltmeter No. 1, the more rapid

FIG. 3.

FIG. 4.

the vibrations, the more E. M. F. is required by the contact breaker. Inasmuch as the contacts are in a high vacuum they will remain bright and effective, and the light is regulated without the use of bulk resistance. Again, with this arrangement the current is not thrown on or off the filament suddenly, thus increasing its longevity owing to more gentle treatment. The slight sparking in lamps individually regulated will use up the residual oxygen in the evacuated bulb of the lamp, thus making it more perfect, and lengthening the life of the lamp.

It was curious to note that practically as well as theoretically an armature suspended, as shown in Fig. 2, is never perfectly at rest. When a photometrical test would probably decide that the

lamp was burning at full C. P., and the screw A pressing the armature B as tightly as the construction of the apparatus would allow against the core of the magnet, if a sounding board is brought into requisition the vibrations of the armature are plainly discernible.

An automatic make-and-break, or varying-in-pressure contact, or what has commonly been called, and what has long been sought after, a scientifically formed "poor or imperfect contact," can be used in one sense as a transformer. It will be interesting to note the effect of a large number of lamps of this description working at one time from one dynamo, because if they should accidentally become synchronous the load on the dynamo would be very varying. But such a result is probably impracticable if not impossible.

Now let us again refer to Fig. 2 and note the changes as the lines of force acting on the armature vary.

The vibrator is in series with the lamp, because if in shunt, the action is reversed and the liability to short-circuit makes it impracticable.

(1) A and B separated, lamp out.

(2) A and B in contact, lamp full, because B is not in magnetic field of magnet.

(3) Continue to advance A, B enters field, rapid vibrations commence and lamp suddenly becomes dim.

(4) Continue to advance A, lamp gradually brightens until full C. P. is reached.

Fig. 5 shows these periods reproduced diametrically. It will be noted that there are two periods where the lamp can be regulated. Period 2—3 is of too short duration for practical application, however, and by the proper adjustment of the spring can be done away with entirely. Period 3—4 covers the greatest range in C. P. and should be used. The delicacy of the spring supporting the armature determines somewhat the position of point 3, that is the minimum in C. P. of the filament.

The voltaic arc appears between the terminals of a source of electricity. In the case of the arc lamp, it consists mainly of volatilized carbon. The electrodes are therefore consumed, first by actual combination with the oxygen of the air, second by volatilization. The ohmic resistance of the arc increases with its length and decreases with its area of cross-section. Polarization sets up C. E. M. F., and the extra current produced by self-

induction retards magnetic action and causes more sparking. With metallic electrodes the color of the arc is characteristic of the metal and is of greater length for the same current than that formed between carbon electrodes. To cause electrical vibratory motion, the current must either be greatly weakened or broken. This will cause sparking which when the life of the contacts is taken into consideration (even though they be in vacuo) should be reduced as much as possible. However, further experimenting may prove the possibility of current regulation by varying the length of the arc in vacuo by means of an exterior magnetic field. Also the construction of a truly incandescent arc lamp on this principle.

Sparking can be relieved in many ways:

- (1) Sub-divide the current as much as practicable.

FIG. 5.

(2) The more rapid the vibrations the more rapid the make-and-break, and consequently the less the spark. To cause rapid vibrations, the point of application of power should be as close to the point of oscillation as possible, or the point of contact should be as far from the point of oscillation as possible.

Magnetic blast, condensers, non-sparking metals, unlike electrodes, high resistance, sheath of copper around bobbin of magnet, metal foil between layers of magnet, separate coils, etc., are all familiar methods.

It is the c. e. m. f., or automatic "choking effect," of the alternating current that permits of its beautiful control without loss, such as is sustained by controlling the direct current entirely with ohmic resistance.

With the method under consideration, the C. E. M. F.'s of the pulsating or intermittent direct current are taken advantage of. That is, both those in the arc and in the magnet.

Besides, when controlling current entirely with ohmic resistance (which can never be completely annihilated), it is constantly in circuit, whereas with the method proposed for lamp control, the only ohmic resistance, that of the arc (that of the magnet being insignificant), is in circuit but one-half of a unit of time, and if there be any foundation for the theory of the persistency of the vision of the human eye, then the filament of the lamp is also dissipating heat but one-half the time. Some energy, however, is expended in the continual magnetization of the armature; in fact, this is another reason why the glow of the lamp filament is diminished and why there is a C. E. M. F. in the magnet. The greater the magnet capacity, the less the self-induction and impedance.

The two greatest desiderata in connection with the advancement of electrical science, and those which, because they have not been satisfied and fulfilled, have, in a measure, for a number of years barred further progress in the most rapidly advanced industry in the history of the world; are first, the use of the efficient low voltage lamp on the efficient high voltage current, and second, the prolonging of the life of these lamps. The manufacture of high voltage incandescent lamps is a subject much agitated at present, owing to the fact that the benefit to be derived from a high voltage is almost incalculable, as the capacity of the mains now used by central stations might easily be trebled. But not only does the successful solution of this problem seem impossible in this direction, but it is now unnecessary. The greatest advantage of the alternating system over the direct current system is, that by means of converters, lamps of low resistance, and therefore high efficiency, can be used. It appears then, that the main advantage (without some disadvantages) of alternating systems can be transferred to the continuous system by using in each socket, or on every circuit, varying pressure contacts, causing an interrupted current of any desired voltage, thus increasing the possibilities of this system to an enormous extent owing to the immense saving in copper conductors.

If an appurtenance of this construction is operated by a centrifugal governor attached to a motor, the best results as regards economy and regulation can be obtained, as the voltage will then

vary directly as the torque, and the electric energy required will be proportional to the power developed. Owing to the minimum size of this device it can be made an integral part of the motor. The salient disadvantages of a resistance box that can now be overcome by constructing apparatus as described, are, first, size; second, weight; third, susceptibility to changes in temperature, that is, variation in resistance; fourth, poor contact caused by the burning of clips and loosening of wires; fifth, heating and the great fire risk consequent thereto. The new

FIG. 6.

FIG. 7.

method is certainly unique, and its application will be the means of affording a great convenience under many circumstances.

Owing to its constancy, due to its non-susceptibility to temperature changes, it can be adopted, when the adjustment screw is used in connection with a graduated dial, with great facility as an electric gauge.

Experiment shows that the continuous sparking (though slight) of the contacts in a vacuum, sets in motion the ether molecules

causing that beautiful soft blue phosphorescent light similar to that produced by Geissler tubes. While Maxwell was the first to note that a disruptive discharge was oscillatory and set up vibrations in the ether, Professor Henry demonstrated it experimentally. The conductive discharge which occurs when vibrating metallic electrodes are used, and therefore of small resistance, probably consists of partial discharges producing oscillations which in turn are due to the induction of the current upon itself in the magnet. But the quantity of current passing, bears a relation to the amount of disturbance and the greater the impedance the less the current; also the more rapid the vibrations or frequency of interruptions, the more prominent becomes the self-induction and the less the true ohmic resistance in the control of the current. These oscillations are increased if the arc is in a strong magnetic field, as it raises the E. M. F. but deteriorates the electrodes more rapidly. If this magnetic field be variable, the effect is magnified, and since free atoms or molecules are made to collide with one another by varying the surrounding potential, we can in a measure account for this phenomenon in that theoretically following every impact the electrostatic force falls from its maximum quantity to zero.

Now by increasing this effect, a light may be produced of greater efficiency than is now obtained by the incandescent filament which is very inefficient. This method of lighting is a radical departure from anything heretofore proposed, as it will be producing phosphorescent light due to ether oscillations without the use of an alternating current (although there is no reason for not using it) at high tension, with expensive and impracticable condensers and transformers. The value of this system will be more clearly discerned when it is remembered that the elements above mentioned as being done away with, are those which stand in the way of phosphorescent lighting becoming commercial at present.

Merely the use of this simple and inexpensive device with the direct or alternating low tension current, produces phosphorescent light. There is no objection, however, to using high voltages; the effect is simply increased, because the greater the stress between the terminals and the more intense the magnetic field, the more rapid will be the interruptions of the current. And the greater the number of impacts per unit of time, the more intense the heating effect and the more economical the light will

be. The most economical potential (there must be such) for given electrodes can only be found by trial, because the greater the heat the less the permanency of the vacuum. The phosphorescence is probably in a measure at least caused by the atomic disturbance due to the actual mechanical movement of the armature in the vacuum; the impacts and the static electricity that may be caused thereby in conjunction with the rapid disruptive discharges. This disturbance or action of varying electrostatic force consists in the rapidly moving or vibrating of charged atoms or molecules coming violently in contact with one another, producing friction, heat, light. In fact, the generation of light due to friction within or without a bulb containing rarefied gas, and caused by inductive action, is a subject of much interest. Experiment seems to indicate (see plates 8 and 9, L, R, S, T, W, X) that the amount of phosphorescence depends more on the number of contacts in different parts of the vacuum per unit of time than on the influence of a surrounding magnetic field.

By reason of the enclosed space in which miniature incandescent arcs can be made to occur in rapid succession throughout its extent, the heat resulting therefrom is conserved and aids in accomplishing the result sought for, a luminosity of maximum radiation emanating from a source of considerable area.

If any inert gas, such as oxygen or nitrogen be substituted for the vacuum, the phosphorescent effect will most likely be intensified on account of more vigorous molecular action, but the life of the electrodes may be shortened. It might be advisable with metallic electrodes to use carburetted hydrogen, because when decomposed it would not affect the metal. Owing to the actual contact of the electrodes, their volatilization or disintegration due to the arc is reduced to a minimum, that is much less than is the case when high tension discharges occur. Of course, the degree of disintegration and the amount of deposit in the bulb depend largely on the nature of the electrodes, aluminium probably being the best. However, the more perfect the vacuum, the less the deoxidization and volatilization, because combustion requires oxygen.

Fig. 6 shows one form of phosphorescent lamp complete, its size a little larger than the base of an ordinary lamp, the c. p. being developed by multiple contacts.

A matter of great importance in the design of a lamp of this description is the form and nature of the evacuated space, partially determined by the melting point of the glass, also whether

FIG. 8.

it is advisable to use double or even triple bulbs, one within the other.

Fig. 7 denotes one of the many forms of lamps that suggest themselves, but experience only can prove that which is most efficient.

The study of this branch of physics and of these highly interesting phenomena brings to our minds innumerable ideas in connection with them, which cannot be treated individually in a short paper. A few only of these ideas are illustrated in plates 8 and 9.

It will be noted that the point in Fig. A is that the bulb does not contain the armature, but is mounted upon it, and therefore can be made very small. As shown, its operation is due to the principle of momentum. This is not the best form for producing phosphorescence, in that the heat in the armature caused by dynamic action is not dissipated in producing molecular disturbance in the bulb. Fig. B, elasticity of the glass bulb is suggested. Fig. E, rapid vibrations and quick break. For rapid action use short, thick magnet. Fig. L, friction within bulb and electromagnetic rotation. Figs. M and N, resistance boxes where gravity is utilized in place of springs.

In Fig. N carbon plates are used for the electrodes, and the bulb should be made of the first quality of refractory glass. On account of the expansion of the gases, formed by excessive sparking, a valve is shown to permit of their escape before a disruption of the glass could occur. This pressure, together with the absence of combustion, bears an important relation to the disintegration of the carbon.

P, is a graduated dial attachment to indicate character of current passing. U, vacuum piston instead of spring. W, movement of metal screens upon each other, pendulum action, producing maximum sparking. T, screen with revolving brushes, resulting in a brilliant phosphorescent lighting effect. V, suggests transmission of light by phosphorescent tubes generated in concealed portions o o.

Owing to the immense production of incandescent lamps, the manufacture of evacuated bulbs has been so perfected and cheapened, that general current control with this system will probably be many per cent. cheaper than any method now in use.

There is a large variety of rheostats and current controllers

FIG. 9.

on the market designed to be used medically, and since the interrupted current, owing to its peculiar effects on the human system, is now being used in medicine, no better form of current controller could be devised than by employing the principle under consideration, as more delicate currents can be supplied than by any other method or means, owing to the steady rate of vibration caused by the non-deoxidization of the contacts in the vacuum. This is clearly proven in that the pitch of the note produced by the vibrating armature is almost constant.

A varying-in-pressure contact could be used with advantage in connection with all delicate measuring instruments. It would materially aid in making them "dead beat," as it could then be made impossible to strain them by suddenly turning on and off the current.

It is hoped that this paper has been of interest to the Institute, and that it will give new impulse to investigations leading to the discovery of a more economical method for transforming mechanical motion into light, and an ideal means for controlling electric currents.

DISCUSSION.

THE PRESIDENT:—You have heard Mr. Moore's paper. The discussion on it is now in order. You will bear in mind that it is generally understood that all papers presented to the INSTITUTE are open to free discussion.

MR. LAURENCE J. ZIMMERMAN:—Some time ago, while experimenting in another direction I obtained similar results by using incandescent lamps. But I came to a different conclusion altogether from that of Mr. Moore. He says in substance, that the light varies in brightness, owing to a more or less perfect or imperfect contact, resulting from varying the pressure at contacts. But I came to the conclusion from my experiments, that the light varies because the watts which are actually delivered to the lamp vary in proportion to the time in which the lamp is actually in circuit during a unit of time (it being apparent that the lamp is in circuit only while the vibrator spring and contact point are in contact electrically), or to put it into a mathematical expression:

$$C \times E \times t_1 = X$$

in which X is the watts delivered to lamp, when t_1 is less than a unit of time, t_1 is the time in which the lamp is in circuit during a unit of time, and CE is the current and E. M. F. or watts consumed by lamp at full c. p.

In my experiments I did not use a vibrator such as Mr. Moore describes; I used a commutator of peculiar construction, in which the contact was as nearly perfect as a brush and commutator contact could be, but obtained the same results as Mr. Moore did with a vibrator, showing that such results could not have been caused by a varying pressure at contacts, or by poor or imperfect contacts.

MR. CHARLES CUTTRISS:—I would like to ask about a few points, because I had occasion ten years ago to use an incandescent lamp, so arranged as to produce this very effect. This was in the winter of 1883. I used it on some small eight candle power lamps I got from England, and it was practically used during the most of the winter. The difficulty I found was that it ran nicely for an hour or an hour and a half, but by-and-by the points would oxidize, or rather build up. In two or three hours, the lamp would go up to its full candle power. But in the experiments I was conducting at that time, the defect was immaterial, because I could trim the points up again and continue. This is one point,—I would like to know if Mr. Moore finds this trouble on a three or four hours run? Last year I built a device almost exactly like the one he shows in his drawing. I have a socket in my pocket that I built then, and the trouble I found with that was very much the same. It would not remain constant. The effect was very nice while it remained constant. But, in spite of all precautions, the points would build up, or would fuse. My idea was that it might be useful for a

sick room. In the day time, when noise was around, you would not notice the hum of the armature, but as soon as the room got quiet you would think there was a dozen mosquitoes right around your head. I could not reduce that noise. It is quite possible, if I put it in a vacuum with a vibrating armature, that the sound would not be transmitted. I merely mention this to show that the idea has been used years ago to a certain extent. It certainly is practicable. Whether it is practicable to leave it all night, or not, I do not know. I would like to know whether Mr. Moore can answer the query as to whether the points build up and alter the rate of vibration in that way, and whether he finds humming to an extent that would be annoying to a nervous person.

MR. MOORE:—It makes a great difference whether the contacts are in a vacuum or not. It was to obviate that very trouble of the inconstancy of the vibration, that the idea of putting the contacts in a vacuum suggested itself to me. Without the vacuum, the system appears impracticable, as upon it depends the steady or constant rate of vibrations, that can be obtained by no other means. The noise can be avoided by being careful in the construction of the vacuum, not to place the armature too close to the glass. With the device properly designed, there should be no noise at all—either with or without a vacuum.

MR. EDWARD P. THOMPSON:—The last speaker but one, said something about the idea being old. Very often ideas are old, but they are not on record. I am able to say that the combinations set forth by Mr. Moore, are new, so far as the records are concerned of the patent offices of three or four different countries. It seems to me that such a device has certainly got to come into use, before *domestic* lighting can be pronounced successful. In business places no need for regulators exists, except for purposes of economy. Perhaps others here, as well as myself, have been asked by people, "Why is it that regulators are not put on incandescent lamps, so that we can have the same use with them as we can with gas?" Sometimes that objection has been answered by saying that the lamp can be turned off, and you do not need any match to light it again. But it is often necessary, without regard to any other consideration, to be able to turn down the light, or to modify the light, in dwelling houses. In reference to any controller outside of electrical means, I came across a certain kind of controller, too simple perhaps to be mentioned before an electrical society, but at the same time a patent was granted upon it several years ago. The claim reads about like this: "In combination with an incandescent electrical lamp, of an openable, opaque cover." It is used on ocean steamers, and on the Chicago, Milwaukee and St. Paul R. R. It is very easy to see that you will not have any electrical difficulties there. The patent was sold at a very fair price. You might say it would be anticipated by some kind of cover for a gas lamp or for an oil lamp. But in those cases you could not cover up the

lamp and yet allow the supply of air for the support of combustion to come in, and the products of combustion to go out. That is about as simple a device, as I suppose you will ever get, in the way of regulating the light, where convenience and not economy is desired—simply have a cover that can be opened more or less.

MR. LOCKWOOD:—I confess that my train of thought has largely run upon the same line as that of the last speaker. Of course, it is quite impossible that a paper presenting such radical features as the paper we have listened to, should be presented without drawing forth considerable discussion, and I think it is unnecessary to say, discussion largely of a critical kind, and that certain, at least, of the views presented in discussion must necessarily be opposed to those presented in the paper. Perhaps that is due to the less amount of thought which the persons hearing the paper have been able to bestow upon the subject. But it is invariably so with great reformers—they have always met with a very considerable amount of opposition—from Luther down.

If I understand the thought of the paper, it is that the method of adjustment of regulation proposed, is that of interposing a variable contact in the circuit, preferably enclosed in a vacuum, and of substituting this for the ordinary determining resistance coils. The paper, I think, does not state in terms that the contact should necessarily be vibratory. On page 438, it is stated that, "The regulation of intensity of the incandescence of an electric filament has been a problem, the solution of which has been sought after by electricians in general the world over, and partial success has been attained by the use of the only known means, 'dead resistance'." The author has apparently forgotten the alternative of shunts. But I suppose that he will consider these also to employ waste of energy. Few of us, Mr. President, I apprehend, are unaware that a vibrating contact in a circuit raises the average resistance of such circuit, or that the variations of the range of the vibration also varies that average resistance. It may also be, that some of us have contemplated an industrial application of these facts. But I scarcely think that any of us would have thought of calling them an "uninvestigated branch of electric science." The author is undoubtedly correct in his view, that in operating such an appliance in connection with an incandescent lamp, a large portion of the result achieved is due to the counter E. M. F. of self-induction, owing to the alternate magnetization and demagnetization of the electro-magnet. If I remember rightly, Poggendorf, in 1855, as recorded in the *Philosophical Magazine*, made some experiments with induction coils, in which the circuit-breaking points of one coil were used to control the magnetization and demagnetization of the other, and the effects at that early period, were by him ascertained to be mainly attributable to self-induction. But I think Mr. Moore will find, if he pursues the subject, that at least some portion of it is properly attributable to the real resistance of the vibrating

contact. In my special branch of electric work we find that there is very considerable margin indeed, between the lowest and the highest resistance of two contacts which are not in constant vibration, when they are set into vibration by the human voice. There are, however, Mr. President, as it seems to me, two very cogent reasons which tend to prevent an appliance from going into use. One is, that the appliance is not known,—a very good reason, I am sure you will agree with me; and the other is, that it is not wanted. I suppose that there are also two reasons which may operate to prevent a known thing from being wanted; one is, that there is no call for the function which it subserves; the other is a general amount of distrust as to the trustworthiness of its operation. It is perhaps a fact that in private life we really see more of the uses of incandescent lamps, than we do in the study of electrical applications, and I think the average user of an incandescent lamp is perfectly well content either to have it turned out, or turned on to its full strength. Of course, the theatrical representations, such as are mentioned on the first page of this paper, do require different degrees of light, and it has occurred to me that in preference to putting an electro-magnet and a vibratory contact in each lamp, or associating one with each lamp, it would be better to adopt the expedient suggested by the last speaker, and have a certain amount of opacity in some of the globes, perhaps making the globes of different colors, and that this, together with the ordinary resistance contrivances, would be more likely to give general satisfaction and be more economical in the long run, than would the expedient suggested by the paper.

Now if we come to the absolute merit of such devices as are suggested, I call upon the gentlemen present who have ever been connected with the telegraph business, to bear me witness that a man would not wish a worse thing to happen to his worst enemy than to have a loose contact in the circuit of a translating device. Any person who has had the privilege of locating a swinging break [laughter], will be able to appreciate the danger of such a perpetuated loose contact. One of the evils of such a thing is, that it is impossible to make a loose contact stable. It is a good deal like the electro-magnetic leaks of our friend Professor Silvanus P. Thompson, by which he hopes to achieve telephonic transmission through the long ocean cables. I have been acquainted with certain telegraphic and telephonic lines, in which permanent leaks have been established of given resistance and given impedance. But it was also impossible to keep them just so, and the resistance and impedance of such leaks would grow less in spite of all we could do. It is another illustration of that pet theory of Professor Oliver Wendell Holmes, or perhaps it was Edward Everett Hale—at any rate it was a Boston man—who believed in the total depravity of inanimate things. Now earth leaks, as we all know who have ever done any testing, are very difficult

to obtain if we want them. If any one goes out to make a test on a line and has to hunt for a ground, it is a difficult thing to get one. On the other hand, if you do not want an earth leak, you can find them on every bush. I say this from actual practical experience that there is no going back on, right here in New York City.

There is one other thing that had almost escaped my attention. Telegraphers know how unstable is an instrument depending on a spring adjustment. There have been times in the telegraphic experience of this country when an operator has fought for circuit perhaps twenty-four hours. I know of one case where an operator fought with the clock all night for circuit. But there have been many times when there has been no clock in consideration at all, but when there have simply been weather troubles, and on account of leakages pretty well disseminated over the circuit, it was quite possible for a single circuit to have three independent messages going on, one at each end and one in the middle. That, of course, was only possible when there was a battery in the middle of the line. It was not possible to keep an adjustment five minutes in twenty-four hours. I rather think that such an adjustment is an unstable and untrustworthy thing to connect with translating devices that we have to work with day after day.

I think there is no call for incandescent lamps that will turn low. One of the greatest merits, it seems to me, of the incandescent lamp is that it is a particularly simple and uncomplicated contrivance, something that the wayfaring man, even though a butcher or restaurant keeper can unscrew if it breaks, and screw another one on without any trouble. We do not want any electrical appliance which is provocative of profanity. Some little time before we adjourned for the summer recess, one of our esteemed members, Mr. Carl Hering, read a paper which, as I remember it, indicated that lamps were kept in use too long anyhow; that it was desirable that lamps should be discarded before reaching their limit of life, and that it would be conducive to economy to discard them at some prior period, (and so far as I could see, and I had the honor of being in the chair on that occasion, where I could see the faces of all the members,) that paper met with a marked degree of approval. Now the excellence, as I have said, of that present incandescent lamp is its simplicity, and it is not at all difficult to imagine an aged and irascible man wrestling with a lamp such as depicted in the paper, but slightly out of adjustment, until the lamp reaches, what Mr. Carl Hering denominated in that paper, its "smashing point."

MR. EDWARD P. THOMPSON:—A former speaker has taken sides partly against the contents of the paper. I would like to try to counterbalance the effect by a few brief remarks. I followed the paper through, and the tone of it strikes me as experimental and

theoretical, rather than relating to a perfected device. The gentleman who just spoke, has alluded to loose contacts and the undesirability of the same, but Mr. Moore proposes to overcome these difficulties, by the use of an evacuated space around the contacts. Mr. Moore is, I think, entitled to the credit of proposing and experimenting upon vibrating contacts in a vacuum, combined with means for varying the rate of vibration for purposes of regulation. As to the practicability of his devices, no one could probably foretell at this stage.

Vibrating contacts outside of an evacuated chamber, produce an unpleasant though faint buzz, which should be largely reduced in the absence of air. Wasting or burning away of the contacts should also be diminished in a vacuum. By having the contacts always in contact in a vacuum, and arranged to vary in pressure upon one another, (as for example, by the use of carbon) as intimated by the author, the sparking should be practically nothing. His proposition for thought and experiment upon making a regulator by using successive and intermittent impulses, so rapid as to be imperceptible, and means for regulating the rapidity of succession or duration of impulses, is worthy of attention and further experiment, especially if directed to the application of an exhausted bulb. The great aim should be to discover if it is possible to effect the reduction of the current to zero between the impulses.

MR. W. J. HAMMER:—I believe there is a very large field for the application of an incandescent lamp that can be turned up and down. I say this, after looking through the subject pretty thoroughly. I would like to call attention to the clause which Mr. Lockwood referred to, on page 438, in which it is said that "The regulation of intensity of incandescence of an electric filament has been a problem, the solution of which has been sought after by electricians in general the world over, and partial success has been attained by the use of the only known means 'dead resistance.'" I do not see any reference in the paper to that beautiful little device invented by Ries, and known as the Ries regulating socket, which contains a reaction coil or choking coil, or as it may be termed a transformer with one winding—the light being controlled by cutting in and out of circuit sections of the coil, and thus changing the ratio between the impressed E. M. F., and the counter E. M. F. produced by an alternating current. That is a little piece of apparatus that has proven highly efficient. It has met with extensive use. In this connection I might say that shortly after Mr. Moore devised this socket I had the pleasure of seeing and handling it. At that time it was in its simplest form, a vibrator in connection with a socket, and I tried it and it certainly worked very well. I told Mr. Moore and the gentleman associated with him that I did not believe in its practicability, for the very reason that Mr. Cuttriss mentioned, that it would oxidize and build up very

shortly. But Mr. Moore spoke then of using such things as shunts and condensers, and putting it in a vacuum, and various other ways which he called attention to in this paper, and I agreed with him then, that the use of a vacuum arrangement would probably be the most efficient, if it could be done. He seems to have accomplished it. I think the paper shows a good deal of knowledge for an experimental paper, and from the little I saw of the apparatus, I think it is well worthy of the consideration of the INSTITUTE, and if he succeeded in making that work by employing the contacts in a vacuum, I should think that he had something that was more or less of a commercial article. Certainly there is a large field and a considerable demand for an incandescent lamp that will regulate. If I was standing on the platform there and reading a paper, I would be very apt to wish to turn that electric lamp up a little higher. Mr. Lockwood speaks of the "smashing point" of an incandescent lamp with such a regulating device in a humorous way. I presume, his experience with the average telephone has suggested such a contingency.

MR. P. B. DELANY:—I simply wish to state, Mr. President, that I have had some little experience with automatic vibrators in the field of telegraphy, and therefore can testify as to the stability of even open contacts, and their wonderful reliability. I was very much interested in Mr. Moore's paper to know what the effect was in putting an automatic vibrator in a vacuum. I had always conceived the idea that such a vibrator would be much more reliable and steady than when exposed to the air, not only on account of the sparking at the point of contact, but of the air displacement. Mr. Lockwood, referring to the experience of telegraphers, very properly describes the annoyance of loose contacts, but surely he knows as well as anybody that all automatic vibrators depend for uniformity of vibration upon the contact that is made between the contact finger and the vibrating reed. In regard to apparatus that may be controlled by such vibrators, it is probably well known that the foundation of the system of harmonic telegraphs, such as Dr. Gray has invented, depends upon the uniformity of pitch of different automatic vibrators, which enable him to work four, five or six circuits. My own experience covers a branch of telegraphy, wherein it was still more necessary than in the Gray system, probably, that we should have an absolutely uniform rate of vibration. In the synchronous multiplex system, automatic vibrators are used, and the contacts are exposed to the air, and all the disadvantages arising from change of temperature, and what is still more detrimental, change of humidity or moisture in the atmosphere surrounding the contact points. And still with the apparatus open to all these detrimental effects the distributor mechanism, controlled by these automatic vibrations, is rotated, with the aid of correcting impulses, without a variation of speed of a five-

hundredth part of a second from morning till night. The system is in use all over England, and requires no particular attention, and yields four or six distinct circuits, according to the length of the wire. Therefore, I am very much pleased to hope that with an automatic vibrator in a vacuum a still more reliable rate of vibration may be obtained. I have always thought it might be so, and I think that perhaps aside from the electric lighting features, referred to in this very interesting paper, there may be other uses found for the utilization of this gentleman's device.

MR. MOORE:—Owing to the great length of a portion of the discussion, I shall be unable to answer it in detail, but in reply to Mr. Hammer's remarks I would say, that I too have often admired the beautiful method of controlling the alternating current that is now on the market. But the device under consideration, can be applied with equal facility both to the alternating and direct currents, and is a much simpler device.

With reference to what has been said on telegraphy, I merely offered that as a suggestion, having in view the principle of harmonic telegraphy.

MR. CHAS. P. STEINMETZ:—I have listened with a great deal of interest to this ingenious paper. I must say, however, that after reading the title, "A New Method for the Control of Electric Energy" and the introduction of the paper, I was somewhat disappointed when I came to the substance of it, and found that it dealt with nothing else but a circuit-breaker acting in a vacuum. Looking more closely into it, however, there are certainly some interesting and novel features in putting the circuit-breaker (which we know from experience, does not work under ordinary conditions) in a vacuum, and so making it a reliable piece of apparatus. In this way I believe the paper offers us a new and interesting idea, but I do not think it should be called "A New Method for the Control of Electric Energy."

This interrupter will, undoubtedly, work very well in incandescent lighting, where small currents are used in non-inductive circuits, but in motor or other work where large currents and inductive circuits have to be dealt with, I do not think an interrupter can work, because it will not break the circuit, but the current will continue to flow and cross the gap as an arc. In an inductive circuit, the flow of current establishes a magnetic field, which represents a certain amount of stored energy, a few foot pounds, perhaps, or many thousands of foot pounds in large dynamo fields, and before the current can be broken, this potential energy has to be expended, and it is expended in an arc across the points of interruption, or if by main force you stop the current suddenly, then the energy is expended by striking through the insulation. You all know from experience with the Ruhmkorff coil and the quicksilver interrupter, that you can make any coil strike through the insulation by replacing the alcohol which covers the quicksilver of the interrupter with a very well insulating oil, so breaking the current quickly.

In incandescent lighting, however, the method will work very well and avoid unnecessary waste of energy, and may as a dimmer of incandescent lights find a large field of useful application.

MR. GANO S. DUNN:—One of the speakers mentioned that in regulating the incandescent lamp, he did not know how much of its diminished candle power was due to the ohmic resistance of the contact, and how much was due to the interruption of circuit, by the vibration. The value of the device depends on this point. In a lamp where the total energy is small, it would be difficult to determine; but I would like to carry the discussion into the domain of motor control, where the amount of energy is large. Taking this device as the counterpart of the choking coil, what is its efficiency as a controller? Mr. Moore mentions that controllers for motors produce heat, which is a waste of energy, and objectionable for insurance reasons. If his device is substituted for the ordinary rheostat, how much energy will be saved, or how much less heat will be produced, for the same amount of regulation? I would also ask, what is the largest amount of power he has ever controlled.

MR. MOORE:—I would state that, of course, this system has not been put into commercial operation as yet, and that the paper before the INSTITUTE, is largely a series of suggestions as to the advantages that may be gained by such a system. If we consider, for example, the case of lamps individually regulated, it is certainly theoretically very efficient. The vibrating contacts are less than .01 of a sq. inch in area.

When the degree of incandescence of the filament is brought so low that it is not discernible to the eye, it indicates that there is the equivalent of 1,000 or 1,500 ohms resistance in circuit, while the measured resistance of the magnet was .4 of an ohm, so that by properly constructing a device which has only .4 of an ohm resistance in itself, you can get a resistance of 1,500 ohms.

MR. DUNN:—The point I wanted to get at was, how hot does the controller get, when it reduces the current in the lamp to say, one half?

MR. MOORE:—The device, when in operation, acquires a temperature equal to that of an ordinary incandescent lamp, and therefore the question of heating is not vital.

MR. A. E. KENNELLY:—The title of this paper is certainly wide, but the contents are narrowed down to a particular application of electric energy. It is suggested that motors can be controlled in this way. But there is no evidence before us that they can be effectively so controlled, and the difficulties in the way, as pointed out, are very great, owing to the large spark that will certainly take place, and the consequent danger of burning up the vibrator. There is, however, a large field for such a device when controlling small currents where the spark is not so dangerous, and no doubt, there is considerable practical advantage to be gained by turning a lamp low. We who use incandescent

lamps much, do not notice this need, because we have accustomed ourselves to dispense with the capability, but persons who have not been so accustomed, do notice it. There are two aspects under which this device may be examined. One is as an energy-saving device, and the other as a convenience-giving device. If it is intended to employ it in a lamp on a 200-volt circuit, and limit with this device the amount of current which the lamp shall receive, so that it shall give sixteen candle-power and no more, that is one way of regarding the question. Or if you take a 100 volt lamp on a 100 volt circuit and simply desire to turn that lamp low and obtain a reduced efficiency with the lamp in process, that is another way of looking at it. It is needless to say that the first method is certainly very advantageous, but very dangerous, because if the vibrator once fails, the lamp will be destroyed. The method particularly defined here is dimming a lamp. From some experiments with vibrating contacts of this description, I take it that the function of a vibrating contact of this kind is only in a minor degree in the resistance of the contact, as you would measure it when metal touches metal. Far the greater advantage lies in the time executed in free space by the spring, when out of contact with the point. It is obvious, that if you give a spring an amplitude of .1 of an inch, it cannot remain in communication with its contact point for more than a fraction of its period and only during that fraction can the voltage be maintained upon the lamp. It is for that very reason that the figures on page 441 give us no reasonable idea as to the relative amount of energy developed in the contact breaker or in the lamp. For example, take the last reading, .02 of an ampere and five volts on the voltmeter across the lamp. One might suppose from that at first sight, that the energy in the lamp was .1 of a watt and there was an energy of 105 volts, multiplied by .02 amperes or 2.1 watts in the contact breaker. That would be altogether, of course, incorrect. In the case of pulsating currents of this kind we can no longer rely on the ordinary multiplication of amperes and volts, because just at the time the current is active, the electromotive force is not active. All we can ascertain from these measurements is, that energy to the amount of the product of full supply pressure, and mean observed current is expended in the lamp and vibrator together. Now assuming that the value of this particular device is contained, for the present at least, in the dimming of the lamp, and its convenience to the public on that account, what we really want to know is, how long will it last. Can Mr. Moore tell us how long a vibrator, operated in this way, will keep at work? Will a vibrator last such a number of hours on trial as to justify the expectation, that the vibration will last the lifetime of a lamp? If there is anything in the paper that it is desirable to know it is that, and I have looked in vain for it in the paper. Probably the convenience of such an attachment would be very considerable if dimming could be effectually

gained, the only disadvantage being, that if anything goes wrong with the contact, you cannot get at it. It is in the vacuum. But let us hope that Mr. Moore has some knowledge that will enable him to give us information as to how long we may expect that contact to last.

MR. MOORE:—In accordance with the experiments that I have made, although I have been severely handicapped in this direction, the contacts have not shown appreciable wear. I have not made continuous runs of 600 or 800 hours. But I have placed the controller in circuit a day at a time, and three or four days in succession, but no change of any consequence occurred. It is a matter of great interest as to what further investigations will develop. As stated, the paper was written in the hope that it will cause further investigations to be made in this line, which evidently, according to good authority, has not been investigated, and is an unexplored field of great proportions,—the exploration of which may be richly rewarded.

THE PRESIDENT:—I should think a difficulty would arise in the actual working of Fig. 3, on p. 441, where the vacuum of a lamp is utilized for the vacuum of the contacts. Here, as I understand, a contact screw passes through the chamber into the vacuum. From my experience with vacua, I should think you would find it difficult to obtain a working vacuum with anything movable entering into it. It might be done, though I question it.

MR. MOORE:—Allow me to explain, Mr. President. The armature and contact only, are in the vacuum. The illustration is rather indistinct; but by carefully examining the same it will be noticed that the magnet is not within the vacuum, and therefore the regulating screw does not enter the vacuum.

DR. WILLIAM E. GEYER:—I think the paper in using the phrase “varying-in-pressure contacts,” implies that the regulation is in large part effected by a change in resistance, self-induction also coming in, and some of the gentlemen who have discussed the paper have assumed that it is largely a question of resistance. I think that is a mistake. As I understand it, this apparatus works not so much by any change in resistance or by self-induction coming in, as by the relative time that the contacts take place. Take for instance Fig. 2. The screw A is far to the left, so that the vibrating portion, B, strikes it only at the extreme end of its excursion. The contact is very short, and the current is on the lamp for just a moment. If the screw is turned further up, the current will last a longer time. The pressure will not be notably greater, and the current is on the lamp longer. When finally the screw is turned up very far, the contact will last for a considerable portion of the time of vibration, and the current is on longer still, and has a chance to heat the filament up. Of course, the time comes when the contact is continuous, and then the current has its full opportunity to heat up the filament. The rate of vibration, as I understand, would make no very particular

difference, because it is only the relative time of contact which counts. If the vibrations are twice as fast, there will be twice as many contacts. The only thing counting is the relative time of contact.

THE PRESIDENT:—I see a distinguished honorary member here. I would like to ask Mr. Preece to take a seat on the platform.

Gentlemen, you see there was wisdom in my having Mr. Moore's paper come in the beginning, for I felt quite sure that it would cause considerable discussion, which it has done, and I wanted to ensure full time for such discussion.

I will now give you a brief inaugural on the International Electrical Congress and World's Fair of 1893.